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Wireless Internet Access Using Spread Spectrum Technology for K-12

Final Report

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I. Summary

Under the NASA High Performance Computing and Communications (HPCC) K-12 program, the Department of Computer and Information Science of Cleveland State University has partnered with NASA Lewis Research Center's (LeRC) to provide cost effective Internet access to area K-12 schools. Among the several alternative approaches considered, some were ruled out as too slow and others were too costly. The use of wireless data transmission using spread spectrum technology seems to be most promising. The radio frequency (RF) spread spectrum technology has the following benefits:

- Quick and each installation
- Elimination of wiring and cable cost
- Fast data transmission rate (2 mbps)
- No recurring cost

A pilot link between CSU and East Technical High School was established to test the reliability and data security and to evaluate the performance of this technology as an alternative to the high cost approach of cabled systems. The tasks defined for this project are summarized below:

1. *Perform requirement study to establish the specifications for necessary hardware and cabling at CSU and Each Tech High School.*
2. *Install "AIRLAN" RF Ethernet bridges and antennas made by Solectek.*
3. *Perform post-installation testing and Monitoring.*

Although there were delays due the renovation of the East Technical high schools, all tasks specified in the project proposal were completed and the result showed the RF link is indeed a most cost effective approach for internet access when appicable.

II. Introduction

Computer and information technology has penetrated every facet of our lives. We experience it at the cashier counter of the supermarket , in the electronic filing of income tax, the array of new telephone services, the popularization of the facsimile. There is no question that the use of computer and information technology is the driving force for change in the modern society.

Recognizing the importance of this technology, educators from primary, secondary and post-secondary education, have scurried to incorporate computer and information technology into curriculum. At the national level, one component of the High Performance Computing and Communication (HPCC) project is to introduce into the K-12 school systems the HPCC technology for the benefit of promoting interest in mathematics, science, and engineering studies. NASA Lewis Research under the realm of HPCC has initiated a K-12 program to carry this mission in Northeastern Ohio. As a result, Garrett Morgan School of Science, Cleveland East Tech High School, Barberton

High School and Fairview High School have been selected for the initial pilot effort. Access to Internet and the Information Super-Highway are among the many objectives of this endeavor.

The Department of Computer and Information Science (CIS) of the Cleveland State University (CSU) in conjunction with Black Data Processing Associates (BDPA) has initiated a partnership with Cleveland Public Schools (CPS) in an effort to formulate strategies for the development of a student-centered information infrastructure for CPS as part of the Vision 21, a grand plan to carry CPS into the 21st century. Coincident with the objective of NASA K-12 program, making Internet available to CPS is one of the objectives considered by Vision 21. However, it is recognized that careful study and planning is required to build Internet connectivity to all CPS schools as they are geographically dispersed and will require a huge capital investment. An intermediate approach which allows low cost access for experimental purpose should be sought. Cleveland State University is networked and has the Internet connectivity through the OANet. One idea suggested was to use CSU as a gateway through some form of connectivity from selected CPS to CSU.

Wireless Transmission Using Spread Spectrum Technology

Several alternatives such as T-1, DDS, RF links for CPS to CSU connectivity were considered. Table 1 compares the costs of various alternatives.

	RF link using SST	**T-1**	**DDS**
Speed	2Mbps	1.5 Mbps	54/64 Kbps
Installation Cost	$2000 (Roof top antenna)	$1,300	$1,200
Monthly Fee	$0	$640	$400
CSU/DSU	$0	$1,500/end	$1,100/end
Remote Ethernet Bridges	$4,200/end	$2,300/end	$1,900/end
Total Cost Year 1	$10,400	$16,580	$12,000
Total Cost Year 2	$0	$7,680	$4,800

Table 1 Comparison of Alternative Connectivity

It is eivident from the table that RF link is the least cost alternative. The use of radio waves as a vehicle of data communication seems to have the potential for further investigation. The wireless connectivity for data networking in the past has been impeded by the small band width, and integrity and security considerations. It only became feasible recently. In 1985, the Federal Communication Commission approved three bands of frequencies (902 to 928 MHz, 2400 to 2483.5 MHz, and 5725 to 5850 MHz) for radio data communications. This made possible the application of spread spectrum transmission technology. In this technique, signals are transmitted over a wide band of frequencies -- a bandwidth that is greater than the bandwidth needed to carry the data alone. Wireless data transmission using spread spectrum technology has the following benefits:

- *Quick and easy installation*
- *Elimination of wiring and cable cost*
- *High reliability and secure radio transmission*
- *Faster data transmission rate (2 mbps)*

It is purposes of this research to evaluate the performance of this technology in an operational setting. The objective of this proposal is to conduct study on the feasibility of using wireless data communication technology for connectivity between CPS and CSU. The result of this initial pilot study can be used to determine the feasibility of using wireless data communication as an alternative to the high cost approach of the traditional cabled systems. The pilot study will begin with establishing an Internet connectivity with the East Tech High School of CPS.

III. Project Activities

1) Selected the Bridges and Antennas and setup testbed in CSU computer lab for testing and evaluation of equipment.

Upon the recommendation from the technical staff from NASA and Sterling Software, Solectek AIRLINE Bridges and parabolic antennas were acquired . The bridges were setup and configured in the CIS lab of CSU. Figure 1 shows the testbed setup. Carnegie Mellon University was used as the FTP site to down files of different sizes and speed of transmission were captured. Same test was done using the wired system for comparison. The test shows wireless approach performed almost at the equal level of the wired approach. The result is tabulated in table 2.

2) Performed Site Survey At CSU and East Technical high school.

This task was done to determine the proper antenna locations at CSU and East Technical High to assure that line of sight existed, all the technical requirements for the installation of the Solectek's "AIRLINE" Bridges and directional antennas are observed.

3) Installed Bridges and antennas and perform diagnostic testing

With Site Survey information an antenna system was designed for each site (See Attached Diagram.) and installed. CSU personnel did the work at CSU site and Syntonic was hired to do the work at East Tech site. It is important to have radio train personnel do antenna work and network personnel do networking to assure the quality of work. The bridges were configured and the antennas were aligned to provide optimal throughput. The RF diagnostic software provided by Sotetnek was run and reported 99% packet transmissions success in both directions.

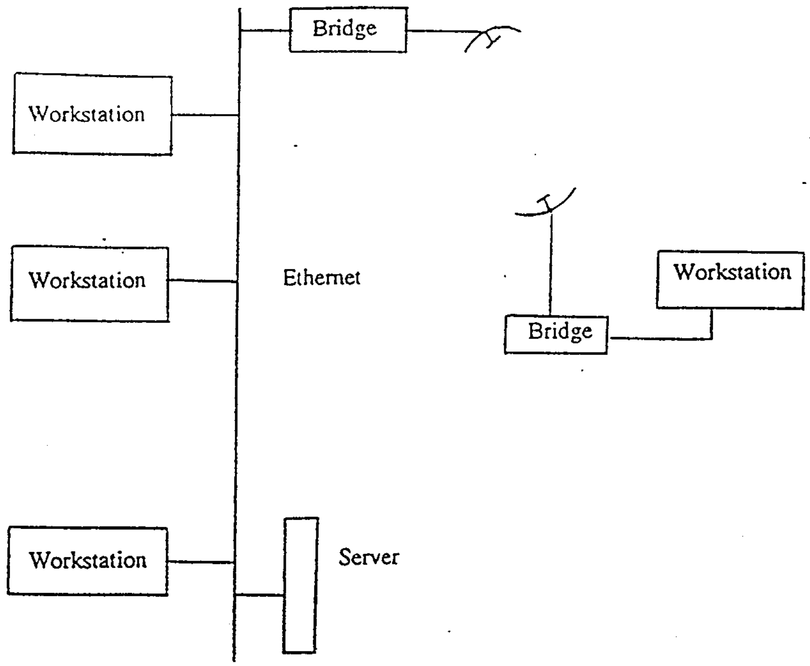


Figure 1. CIS Testbed Configuration

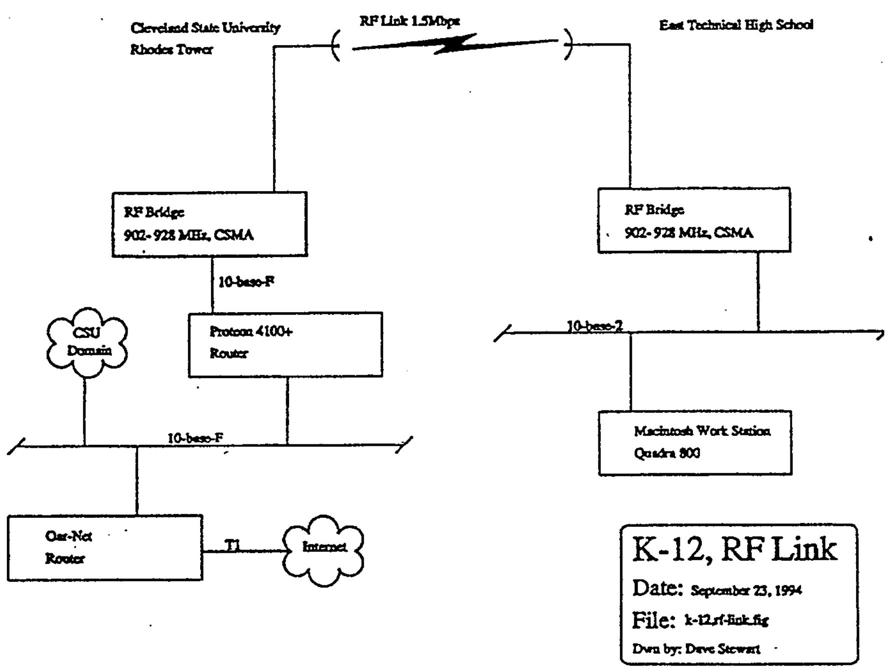


Figure 2. RF Link between CSU and East Technical High School

4) Established network connections

A router and an AUI to fiber transceiver between the RF bridge and the CSU back bone was installed on the CSU site. At the Each Tech high, a 10 base2 segment was installed to remote the Mac workstation. A non-standard transceiver (Apple _AUI to 10 base2) was installed to connect the Quardra workstation of Apple Computer to the ehternet segment. Figure 2 shows the RF link setup between CSU and East Technical High School.

5) Performed debugging and system testing

Initial testing using Mosaic and C-U-See-Me showed good performance of the RF link. However, there were an average 10% packet loss. Through pinging of machines to and from the East Tech site, it was determined that there were near channel interference. Subsequently, we repolarized and realigned the antennas to alleviate the interference. Subsequent test using the RF diagnostic software showed 100% success rate of packet transfer.

6) Performed post-installation tests

Tests runs were made to study the reliability, data integrity and data capacity of the RF link. Section 4 describes the detail of the test results.

V. Performance Analysis

1. We performed numerous continuous pings (1000 pings size of 2000 bytes) with success rates of 99.9%. They were executed at various times of day and on different days therefore supporting that the loss of packets due to channel interference has been corrected.

2. We used Xmosaic, Netscape to roam and browse the Internet without any problem.

3. In order to measure the data transfer rate and reliability, we used FTP to achieve this objectives as FTP (File Transfer Protocol) is a commonly used application and it provides the statistics necessary for our analysis.

FTP - An Introduction

FTP is the Internet standard for file transfer from one machine to another and is usually implemented as application level programs. To use FTP we need an account to login to on the server, or we need to use it with a server that allows anonymous FTP.

FTP uses TCP/IP protocols. TCP/IP is a set of communication protocols that define how different types of computers talk to each other on Internet. The Internet is the worldwide collection of separate physical networks, which grew out of the original APPANET, that uses Iternet Protocol (IP) to link the various physical networks into a single logical network.

TCP/IP software is organized into four conceptual layers that build on a fifth layer of hardware. figure 3 shows the conceptual layers as well as the form of data as it passes between them. It bases its protocol layering on the idea that reliability is an end-to-end problem. The Internet was constructed so it can handle the expected load, but allow individual links to lose data or corrupt it without trying to recover. The transport layer handles most error detection and recovery problems.

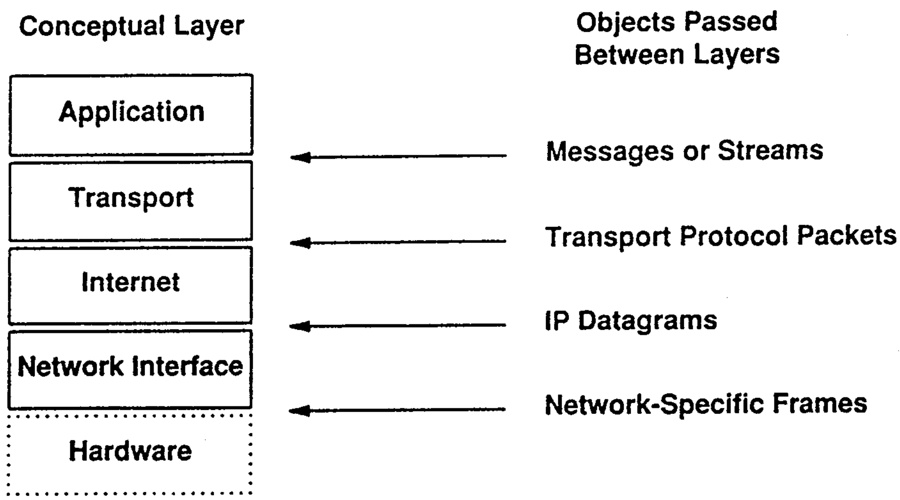


Figure 3 TCP/IP Conceptual Layers

Several prominent TCP/IP protocols are listed below:

TCP (Transmission Control Protocol) - The TCP/IP standard transport level protocol that provide the reliable, full duplex, stream service on which application protocols depend. Software implementing TCP usually resides in the operating system and uses the IP protocol to transmit information across the underlying internet.

IP (Internet Protocol) - the TCP/IP standard protocol that defines the IP datagram as the unit of information passed across an internet and provides the basis for connectionless, best effort [package delivery.

ICMP (Internet Control Message Protocol) - An integral part of the IP that handles error and control messages. Specifically, gateways and hosts use ICMP to send reports and problems about datagrams back to the original sours that sent the datagram. ICMP also includes an echo request/reply used to test whether a destination is reachable and responding.

UDP (User Datagram Protocol) - The TCP/IP standard protocol that allows an application program on one machine to send a datagram to an application program on another machine. UDP uses the IP to deliver datagrams. Conceptually, the difference between UDP and IP datagrams is that UDP includes a protocol port number, allowing the sender to distinguish among multiple application programs on the remote machine. In practice, UDP also includes a checksum over the data being sent. Figure 4 shows the demultiplexing at the Internet layer for the arriving datagrams.

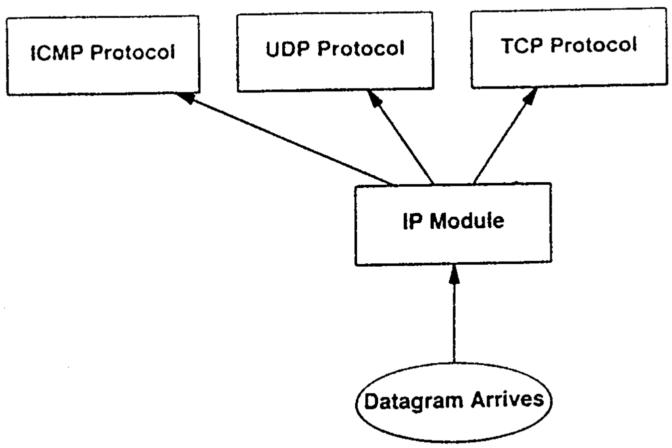


Figure 4. Demultiplexing - Internet Layer

FTP uses two TCP connections to transfer files:

1) The control connection used for command from the client to the server and for the server's reply.
2) A data connection is created each time a file is transferred between the client and server.

The control connection stays up for the entire time that the client communicates with the server while for each file transfer there is a data connection and disconnection. Figure 5 shows the processes involved in file transfer.

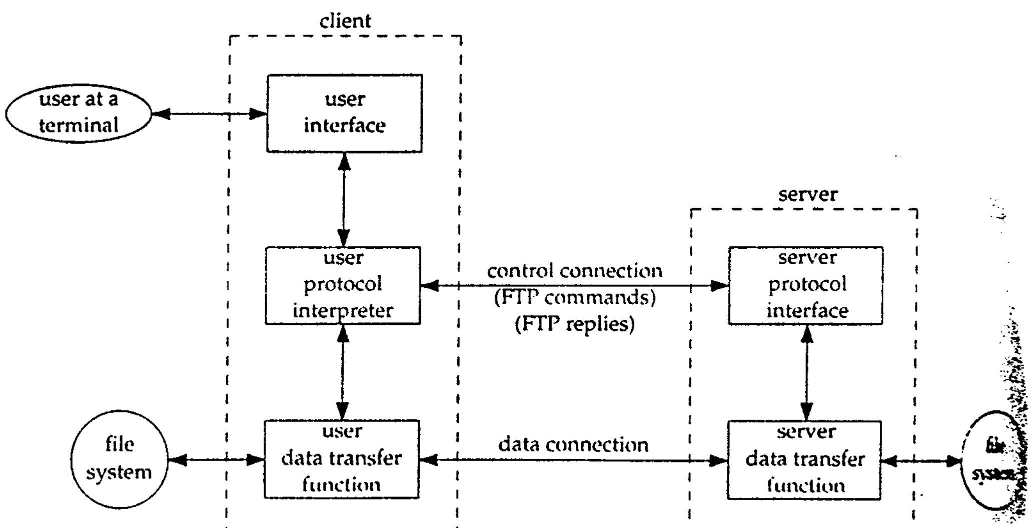


Figure 5 File Transfer Process

a) To gauge the comparative data transfer speed, we first down load a set of files with varying size from Carnegie Mellon University to Neumman (a DEC workstation) in CIS Lab of CSU and to Each Technical High School. The CMU to CSU is through the CSU backbone to the CIS lab's local area network. The CMU to East Tech uses CSU as a gateway and routed through the wireless RF link. The objective of this experiment is to see whether there is a significant difference in data transfer rate between wireless and wired configurations. Table 2 shows the data transfer time and rate (in k bytes per second). Figure 6 graphically displays the result.

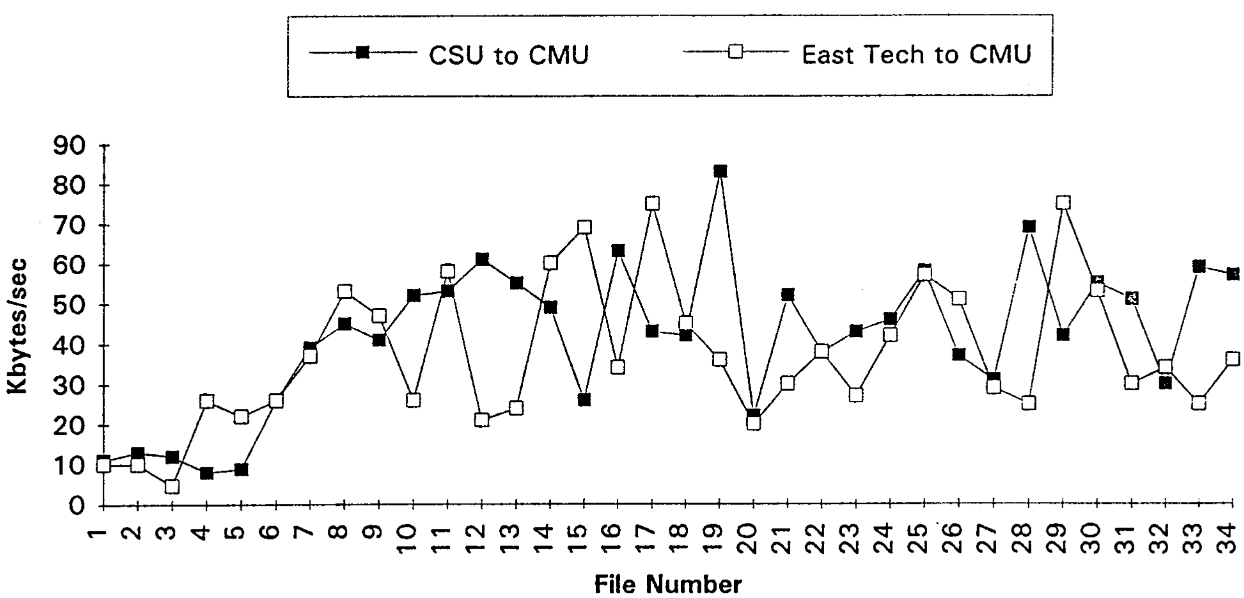


Figure 6. Data Transfer Rate for FTP East Tech/CSU to CMU

b) FTP to East Tech from CSU neumann and FTP to Neumann from East Tech and download the set of files as in a). The result is given in Table 3 and Figure 7.

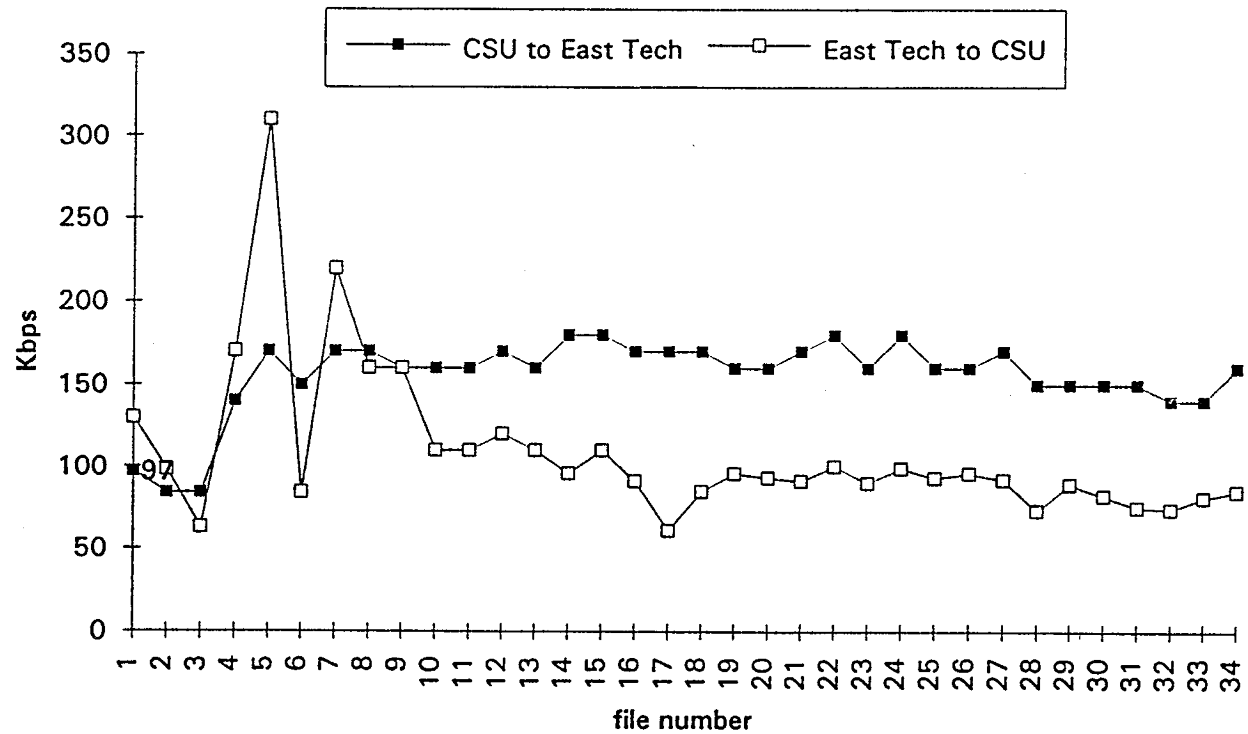


Figure 7. Data Transfer Rate FTP CSU From/To Each Tech

c) Used FTP command "netstat -i" to display status information for autoconfigured interfaces. This command prints the MTU (maximum Transmission Unit) of each interface, the number of input packets, input errors, output packets, output errors, collision, and the current size of output queue. Command "netstat -s" displays per-protocol statistics for various protocols used in FTP (see Appendix 1 for detailedlisting.) The ICMP statistics are especially important as they reveal the extent of errors during transmission.

ICMP:

calls to icmp_error
errors not generated 'cuz old message was ICMP
Output histogram: destination unreachable: #
messages with bad code fields
messages < minimum length
bad checksums
messages with bad length
Input histogram: destination unreachable: #
Message responses generated

The test runs indicated the there is no significant difference between wired and RF links in error production.

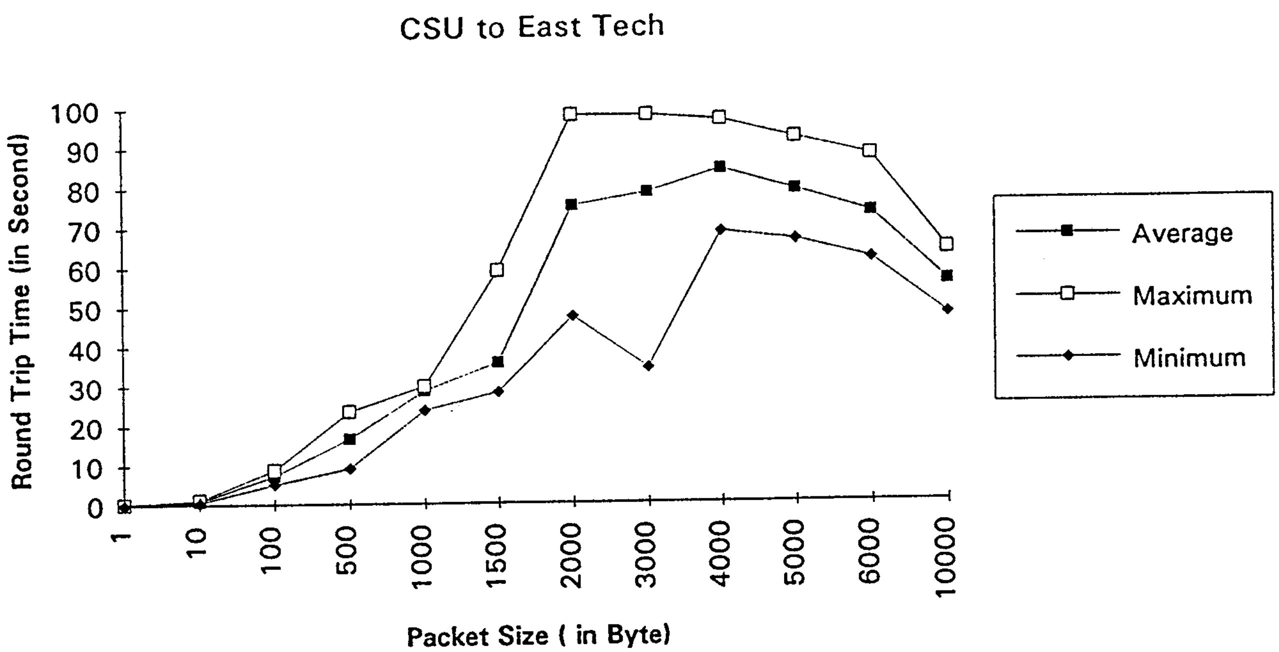
d) Packet Size

Since Internet is composed of a set of physical networks and each network has its own maximum transfer unit or MTU, it places a fixed upper bound on the amount of data that can be transferred in one physical frame (i.e., packet size). Thus, instead of designing the IP datagrams that adhere to the constraints of physical networks, TCP/IP software chooses a convenient initial datagram size and arranges a way to divide large datagrams into smaller packets when the datagram needs to traverse a physical network that has a smaller MTU. The small pieces into which a datagram is divided are called fragments, and the process of dividing is called fragmentation. the packet size is limited to the smallest possible MTU in the Internet.

The IP protocol does not limit datagrams to small size. The source can choose any size it want; fragmentation and reassemble occurs automatically. However, to limit the fragmentation, it is of interest to study the effect of packet size on the transmission time. We conducted an experiment to study the round trip time of data transmission with different packet size. The result was shown in Table 4 and figure 8.

Conclusion

From our experiments, the performance of the RF link to CSU backbone for Internet access is nearly as good as the wired LAN (in this case CIS Lab). The performance is much higher than through the phone line using high speed modem (56k bps). It has the equivalent performance of using TI line with zero recurring operating cost.



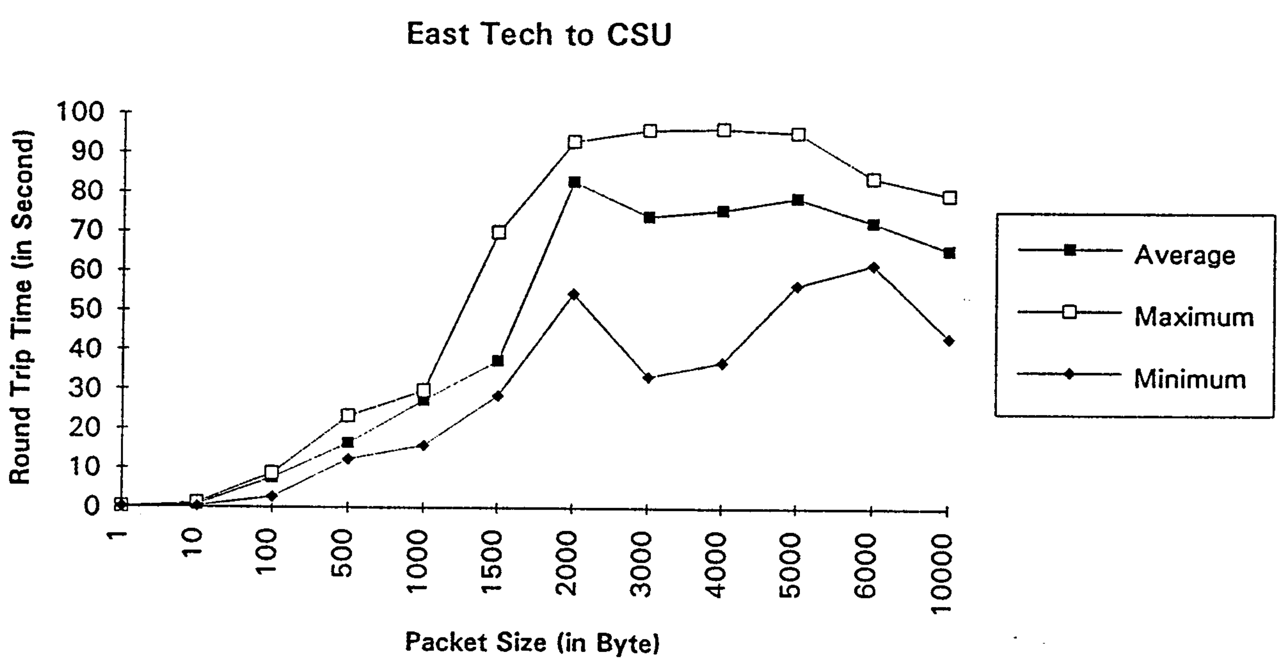


Figure 8. Round Trip Time vs. Packet Size

Table 1. Comparision of FTP from CMU to CIS lab using Wired and Wireless System

Byte	Wired Time (second)	Wired Speed (kbyte/s)	Wireless Time (second)	Wireless Speed (kbyte/s)	Compare
4461	0.41	11	0.71	6.4	+
4539	0.34	14	0.94	4.9	+
4856	0.41	12	0.55	8.9	+
6137	0.36	17	0.83	7.4	+
10327	0.43	25	0.23	45	-
14264	0.57	26	0.68	21	+
17120	0.81	21	0.72	23	-
30720	0.61	51	3	10	+
40960	0.82	51	2.7	15	+
40960	0.98	42	0.99	42	+
49152	0.99	49	1.1	45	+
57555	2.5	22	1.4	40	-
61759	4.9	12	3.2	19	-
66232	2.2	31	2.6	26	+
69773	2	34	4.1	17	+
69872	3.9	20	3.8	20	-
92287	10	8.9	6.2	15	-
115805	2.3	51	5.2	23	+
116900	2.5	46	3.3	35	+
134852	3.3	41	4.1	33	+
143360	8.8	16	5.2	28	-
153600	5.7	27	10	16	+
174080	5.6	31	6.3	28	+
176965	7.7	23	5.4	33	-
204800	4.2	50	5.6	37	+
225280	16	14	12	20	-
243200	13	18	8.5	29	-
245760	30	8.2	24	10	-
325868	15	22	20	17	+
382808	8	47	18	21	+
409600	19	22	15	27	-
455166	21	21	20	23	-
491520	19	26	21	24	+
491520	14	36	15	32	+
896877	20	44	23	38	+

Table 2. Data Transfer Rate : East Tech to CMU and CSU to CMU

file size	From CSU Neumman to CMU			From East Tech to CMU		
	time	kbytes/s	1-27-10:22	time	kbytes/s	1-30-3:06
4641	0.4	11		0.44	10	
4719	0.35	13		0.45	10	
5016	0.43	12		1	4.7	
10707	1.3	8		0.41	26	
14855	1.7	8.8		0.66	22	
17198	0.64	26		0.65	26	
31821	0.8	39		0.84	37	
42406	0.93	45		0.78	53	
42717	1	41		0.89	47	
49961	0.94	52		1.8	26	
57821	1.1	53		0.97	58	
62052	1	61		2.9	21	
68592	1.2	55		2.8	24	
70110	1.4	49		1.1	60	
80027	3	26		1.1	69	
92590	1.4	63		2.6	34	
118768	2.7	43		1.5	75	
118822	2.8	42		2.6	45	
137005	1.6	83		3.7	36	
148693	6.6	22		7.3	20	
159049	3	52		5.3	30	
180172	4.7	38		4.7	38	
182982	4.2	43		6.7	27	
211425	4.5	46		4.9	42	
216755	3.7	58		3.7	57	
230677	6	37		4.4	51	
250103	8	31		8.4	29	
384520	5.5	69		15	25	
422060	9.7	42		5.5	75	
468431	8.3	55		8.6	53	
506432	9.6	51		16	30	
506432	16	30		14	34	
907051	15	59		36	25	
2534891	4.3	57		6.9	36	
average	3.935	41.788235		5.135	36.932353	
min	0.35	8		0.41	4.7	
Max	16	83		36	75	

Table 3. Data Transfer Rate : East Tech to CSU and CSU to East Tech

file size	From CSU Neumman to East Tech			From East Teach to CSU Neumman		
	time	kbytes/s	1-30-3:17:00	time	kbytes/s	1-30-3:20
4641	0.047	97		0.035	130	
4719	0.055	84		0.047	98	
5016	0.059	84		0.078	63	
10707	0.074	140		0.062	170	
14855	0.086	170		0.047	310	
17198	0.11	150		0.2	84	
31821	0.18	170		0.14	220	
42406	0.24	170		0.26	160	
42717	0.26	160		0.25	160	
49961	0.3	160		0.46	110	
57821	0.34	160		0.5	110	
62052	0.37	170		0.51	120	
68592	0.41	160		0.62	110	
70110	0.39	180		0.71	96	
80027	0.43	180		0.71	110	
92590	0.54	170		0.99	91	
118768	0.7	170		1.9	61	
118822	0.69	170		1.4	85	
137005	0.83	160		1.4	96	
148693	0.9	160		1.6	93	
159049	0.93	170		1.7	91	
180172	1	180		1.7	100	
182982	1.1	160		2	90	
211425	1.2	180		2.1	99	
216755	1.3	160		2.3	93	
230677	1.4	160		2.4	96	
250103	1.4	170		2.7	92	
384520	2.5	150		5.1	73	
422060	2.7	150		4.6	89	
468431	3	150		5.6	82	
506432	3.3	150		6.6	75	
506432	3.6	140		6.7	74	
907051	6.5	140		11	81	
2534891	1.6	160		2.9	85	
average	1.13355882	155.441176		2.03879412	108.735294	
Min	0.047	84		0.035	61	
Max	6.5	180		11	310	

Table 4. Round Trip time as a function of Packet Size

100 packets												
	packet size				Ullman to East Tech							
1	10	100	500	1000	1500	2000	3000	4000	5000	6000	10000	
0.02	1.04	5.01	13.05	29.66	33.69	97.07	76.45	92.59	78.67	62.84	48.65	
0.1	0.51	8.59	23.23	29.76	33.45	97.85	34.09	72.36	91.97	69.38	61.78	
0.1	0.38	8.59	23.34	29.79	33.57	97.66	95.93	68.4	71.43	61.57	47.58	
0.11	1.04	8.48	23.27	23.88	58.88	91.91	78.61	70.32	84.58	65.76	58.14	
0.1	0.56	8.62	13.02	23.72	33.57	90.59	94.81	92.52	76.45	80.09	55.92	
0.06	0.56	5.02	16.62	29.76	33.7	55.8	66.74	96.43	90.64	77.6	61.74	
0.1	1.05	4.98	13.03	29.66	33.6	56.19	92.8	90.49	84.58	82.88	47.34	
0.11	0.54	8.59	16.71	29.8	28.18	66.93	96.06	93.12	66.24	87.45	63.58	
0.11	1.05	8.62	12.96	29.79	33.64	47.3	97.79	93.99	70.06	72.12	57.26	
0.06	0.41	5.01	8.92	29.66	33.63	48.45	49.63	69.68	73.93	71.7	55.78	
0.087	0.714	7.151	16.42	28.55	35.59	74.98	78.29	83.99	78.86	73.14	55.78	Ave
0.02	0.38	4.98	8.92	23.72	28.18	47.3	34.09	68.4	66.24	61.57	47.34	Min
0.11	1.05	8.62	23.34	29.8	58.88	97.85	97.79	96.43	91.97	87.45	63.58	Max
	packet size				East Tech to Ullman							
1	10	100	500	1000	1500	2000	3000	4000	5000	6000	10000	
0.05	1.05	4.76	12.28	29.56	29.62	92.62	65.97	95.23	93.42	82.74	71.86	
0.11	0.36	8.59	16.07	29.79	33.64	70.31	90.48	36.99	56.61	66.91	79.49	
0.05	0.52	8.57	23.23	29.62	33.33	54.47	73.46	96.17	95.27	61.83	73.12	
0.11	1.05	8.47	23.02	29.62	33.57	89.14	95.9	76.04	68.35	76.84	69.01	
0.11	0.54	8.57	12.33	29.8	69.82	72.88	33.29	70.32	75.34	83.71	77.78	
0.1	0.54	8.39	12.86	29.76	47.84	92.96	80.64	72.78	90.52	64.35	43.39	
0.11	0.26	8.47	16	18.95	33.6	88.82	90.48	93.21	70.19	70.16	55.61	
0.11	0.53	8.59	15.98	15.88	28.98	89.1	49.02	70.02	64.4	72.67	71.06	
0.11	1.04	8.6	16.02	29.76	28.43	89.31	66.07	76.28	82.45	65.94	67.07	
0.11	0.54	2.55	16.07	29.76	33.6	88.66	93.51	69.21	89.86	79.15	48.18	
0.097	0.643	7.556	16.39	27.25	37.24	82.83	73.88	75.63	78.64	72.43	65.66	Ave
0.05	0.26	2.55	12.28	15.88	28.43	54.47	33.29	36.99	56.61	61.83	43.39	Min
0.11	1.05	8.6	23.23	29.8	69.82	92.96	95.9	96.17	95.27	83.71	79.49	Max

Appendix 1. Protocol Statistics using "netstat -s " Command

```
Script started on Fri Jan 27 10:40:52 1995
# ftp 128.2.13.21
Connected to 128.2.13.21.
220 lancaster.andrew.cmu.edu FTP server (Version wu-2.3(3) Tue Apr 12 17:35:30 EDT 1994) ready.
Name (128.2.13.21:): anonymous
331 Guest login ok, send your complete e-mail address as password.
Password:
230-Welcome, archive user!  This is an experimental FTP server.  If have any
230-unusual problems, please report them via e-mail to
230-<dc0m+netdev@andrew.cmu.edu>.
230-If you do have problems, please try using a dash (-) as the first character
230-of your password -- this will turn off the continuation messages that may
230-be confusing your ftp client.
230-
230 Guest login ok, access restrictions apply.
ftp> cd pubs
550 pubs: No such file or directory.
ftp> cd pub
250 CWD command successful.
440 bytes received in 1.2 seconds (0.35 Kbytes/s)



ftp> get bootp2.1.tar
200 PORT command successful.
150 Opening ASCII mode data connection for bootp.2.1.tar (153600 bytes).
226 Transfer complete.
local: bootp.2.1.tar remote: bootp.2.1.tar
159049 bytes received in 1.8 seconds (86 Kbytes/s)
ftp> !netstat -i
Name  Mtu   Network     Address          Ipkts Ierrs   Opkts Oerrs  Coll
ln0   1500  137.148.205 easttech.csuohi  32867     0   16032     0     0
lo0   1536  loop        localhost           11     0      11     0     0
ftp> !netstat -s
ip:
        32846 total packets received
        0 bad header checksums
        0 with size smaller than minimum
        0 with data size < data length
        0 with header length < data size
        0 with data length < header length
        0 fragments received
        0 fragments dropped (dup or out of space)
        0 fragments dropped after timeout
        0 packets forwarded
        0 packets not forwardable
        0 redirects sent
icmp:
        0 calls to icmp_error
        0 errors not generated 'cuz old message was icmp
        1 message with bad code fields
        0 messages < minimum length
        0 bad checksums
        0 messages with bad length
        Input histogram:
                destination unreachable: 1
                source quench: 3
        0 message responses generated
tcp:
        15946 packets sent
                609 data packets (59758 bytes)
                4 data packets (1522 bytes) retransmitted
                1969 ack-only packets (1608 delayed)
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        0 URG only packets
        1 window probe packet
        13203 window update packets
        160 control packets
    32631 packets received
        865 acks (for 60042 bytes)
        101 duplicate acks
        0 acks for unsent data
        31149 packets (33527898 bytes) received in-sequence
        69 completely duplicate packets (23075 bytes)
        6 packets with some dup. data (381 bytes duped)
        881 out-of-order packets (503334 bytes)
        0 packets (0 bytes) of data after window
        0 window probes
        3 window update packets
        1 packet received after close
        0 discarded for bad checksums
        0 discarded for bad header offset fields
        0 discarded because packet too short
    11 connection requests
    138 connection accepts
    147 connections established (including accepts)
    287 connections closed (including 0 drops)
    1 embryonic connection dropped
    853 segments updated rtt (of 869 attempts)
    8 retransmit timeouts
        0 connections dropped by rexmit timeout
    0 persist timeouts
    2 keepalive timeouts
        0 keepalive probes sent
        1 connection dropped by keepalive
udp:
    90 total udp requests
    0 incomplete headers
    0 bad data length fields
    0 bad checksums
    0 total input dropped


ftp> get BOG.tar
200 PORT command successful.
150 Opening ASCII mode data connection for BOG.tar (245760 bytes).
226 Transfer complete.
local: BOG.tar remote: BOG.tar
253489 bytes received in 7.5 seconds (33 Kbytes/s)
ftp> !netstat -i
Name  Mtu   Network      Address          Ipkts Ierrs   Opkts Oerrs  Coll
ln0   1500  137.148.205  easttech.csuohi  33385     0   16265     0     0
lo0   1536  loop         localhost           11     0      11     0     0
ftp> !netstat -s
ip:
    33359 total packets received
    0 bad header checksums
    0 with size smaller than minimum
    0 with data size < data length
    0 with header length < data size
    0 with data length < header length
    0 fragments received
    0 fragments dropped (dup or out of space)
```